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First record of the rare deep-water benthopelagic genus *Crassarietellus* (Copepoda: Calanoida: Arietellidae) from the high Arctic with the description of a new species *Crassarietellus septentrionalis* sp.n.

Первая находка редкого глубоководного бентопелагического рода *Crassarietellus* (Copepoda: Calanoida: Arietellidae) в Северном Ледовитом океане с описанием нового вида *Crassarietellus septentrionalis* sp.n.

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КЛЮЧЕВЫЕ СЛОВА: Copepoda, Calanoida, Arietellidae, *Crassarietellus*, глубоководный бентопелагический, Северный Ледовитый океан.

ABSTRACT. A new deep-water benthopelagic copepod species *Crassarietellus septentrionalis* is described from the Svalbard area in the high Arctic. The new species shares the main characters of the body structure and the morphology of oral parts and swimming legs with the genus *Crassarietellus* Ohtsuka, Boxshall et Roe, 1994 of the Arietellidae and differs from its congeners in the smaller size, the integument, which is not pitted, some details of the antennule and oral parts armament and the caudal rami seta IV, which is of peculiar swollen shape. An intact male P5 of *Crassarietellus septentrionalis* sp.n. is herein described for the first time for the genus. The genus *Crassarietellus* is for the first time recorded in the high Arctic (81°N). This represents the northernmost finding of the genus.

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РЕЗЮМЕ. Новый глубоководный бентопелагический вид копепод *Crassarietellus septentrionalis* описан из района Шпицбергена из высоких широт Арктики (81°N). Новый вид соответствует роду *Crassarietellus* Ohtsuka, Boxshall et Roe, 1994 из семейства Arietellidae по следующим признакам: строение тела, морфология ротовых органов и плавательных ног и отличается от сородичей меньшими размерами, отсутствием инкрустации хитиновых покровов, отдельными деталями вооружения антеннул и ротовых частей и своеобразной вздутой формой щетинки IV каудальных ветвей. Впервые для рода здесь описана неповрежденная P5 самца по самцу *Crassarietellus septentrionalis* sp.n. Род *Crassarietellus* впервые зарегистрирован в высоких широтах Арктики (81°с.ш.) и эта находка является самой северной, зарегистрированной для рода.

Introduction

The calanoid copepod family Arietellidae includes 52 species in 14 genera that inhabit both shallow and deep-waters of the pelagic and benthopelagic environment of the world oceans. Arietellids constitute a significant component of the benthopelagic calanoid copepod community and their genera are mainly near-bottom dwellers [Ohtsuka *et al*., 2005]. Recent descriptions of new benthopelagic arietellid genera and species contributed to our knowledge of their diversity in the vicinity of the sea bed and demonstrate, that most of the near-bottom genera are rare and monotypic (6 genera), or comprise only 2–6 species (5 genera) [Ohtsuka, Boxshall, 2004; Soh *et al*., 2013; Komeda *et al*., 2021]. The new species of *Crassarietellus* described herein, belongs to the latter group.

Representatives of the Arietellidae demonstrate a wide geographical distribution in the oceans of the

world; however, only species of the pelagic genus *Arietellus* are known from high northern latitudes, from the waters adjacent to Iceland and Greenland [Razouls C. *et al*., 2005–2022].

The genus *Crassarietellus* includes two species: *Crassarietellus huysi* Ohtsuka, Boxshall et Roe, 1994 (known from one female) and the unnamed *Crassarietellus* sp. (known from a male); both are recorded from the deep-waters of the Atlantic Ocean at about 20–21 and 38°N [Ohtsuka *et al*., 1994]. Individuals of the new species described herein are the northernmost reported members of *Crassarietellus*; they are found in the Arctic Ocean.

The new species shares with the genus *Crassarietellus* several important taxonomic characters. However, it differs in some features and is for now tentatively placed in the genus, as little is known about the morphology of the genus in general.

Material and methods

Benthopelagic arietellid copepods of the genus *Crassarietellus* (5 females and 1 male) were collected with an epibenthic sledge [Brenke, 2005] during the PASCAL (**P**hysical feedbacks of **A**rctic, Planetary boundary layer, **S**ea ice, **C**loud and **A**erosol) expedition on board of the RV Polarstern, cruise PS 106–1 in the Arctic Ocean adjacent to Svalbard on the Yermak Plateau slope in 2017.

Specimens were stained by adding a solution of chlorazol black E dissolved in 70% ethanol/30% water. The genital field structures were studied after processing the specimens in a solution of lactic acid/50% water 50%. Oral parts and swimming legs were dissected, mounted in glycerin and figured using a *camera lucida*.

Two specimens were prepared for scanning electron microscopy (SEM). The specimens were taken from glycerol, rinsed with distilled water, dehydrated in an ascending ethanol series and then dried for 10–12 min with hexamethyldisilazane [Bock, 1987]. The preparations were photographed uncoated on a HITACHI TM-1000 scanning electron microscope.

The following abbreviations are used in the descriptions: P1–P5, legs 1–5. Free segments of the antennule are designated by Arabic numerals, ancestral segments by Roman numerals. One seta and one aesthetask on a segment of the antennule are designated: 1s + 1ae, "1?" indicates that a setal element was broken and only the scar at the location of its attachment was counted. Terminology and definitions for the antennule segmentation and setation, antenna exopod setation, maxilla and maxilliped segmentation and setation follows Huys & Bosxhall [1991], Markhaseva & Ferrari [2006], Markhaseva *et al*. [2014], Ferrari & Ivanenko [2008], and Ferrari & Markhaseva [2000 a, b] respectively.

The type material and additional specimens are deposited in Senckenberg Museum Frankfurt (SMF), Germany and the Zoological Institute, Russian Academy of Sciences, St. Petersburg (ZIN).

Taxonomy

Family Arietellidae Sars, 1902
Genus *Crassarietellus* Ohtsuka, Boxshall et Roe, 1994

Crassarietellus septentrionalis **sp.n.**
Figs 1–8.

MATERIAL. Holotype, adult female, dissected, body length 1.75 mm (SMF 37257/1-5), Arctic Ocean, 81°55.43"N 10°05.09"E, PASCAL expedition, station 24–5, 7 June 2017, above the seabed at a depth of 959 m. Paratype, adult female, dissected, body length 1.80 mm (ZIN 91160), same metadata data as for holotype. Additional material, 3 females, body length 1.70 mm (specimen 1, urosome destroyed during SEM study); 1.70 mm (specimen 3) and 1.85 mm (specimen 2, body destroyed during SEM study) and 1 male, body length 1.50 mm (ZIN 91161).

DESCRIPTION. Adult female, total length 1.70–1.85 mm (holotype 1.75 mm); prosome 3.50–4.1 (holotype 4.1) times as long as urosome. Cephalosome and pediger 1 separate, pedigers 4 and 5 fused; posterior corners of prosome produced into rounded lobes reaching posterior end of genital double-somite (Fig. 1A–B). Urosome of 4 somites, integument not pitted; genital double-somite wider than long (Fig. 1E); with large spermathecae directed anteriorly; gonopores paired, and paired copulatory pores are posterior to gonopores, ventral flap absent (Figs 1F–G, 8A–D); 3 integumental perforations, function unidentified, present between copulatory pore and gonopore (8B–D). Rostrum triangular, with 2 filaments (Fig. 1C–D). Caudal rami symmetrical, longer than wide, with vestigial seta I, well developed setae II–VI, seta IV differs from setae II–III and V–VI in the peculiar swollen shape (holotype), seta VII originating dorsally near base of seta VI (Fig.1H).

Antennules (Fig. 2A–D) reaching to the anterior border of pedigerous somite 1 (holotype and paratype), or nearly to posterior border of pedigerous somite 1 (specimen 1, broken in specimens 2 and 3); left antennule of 21 distinctly free segments (Fig. 2A–B), right antennule of 22 distinctly free segments (Fig. 2C–D); armature as follows: I–III–7s+1ae, IV–2s, V–2s+1ae, VI–2s, VII–2s+ae, VIII–XIII–2s each, XIV–2s+1ae, XV–XVI–2s, XVII–XIX–2s+1ae, XX–2s, XXI–2s+ae. In left antennule segment XXII with 1s, this segment is shorter than in the right antennule (Fig. 2A–B), segment XXIII with 1s and fused to segment XXIV, segments XXIV–XXVIII–12s + 2ae (holotype, paratype), or with 13s + 2ae (specimen 1). In right antennule segment XXII with 1s, this segment is longer than in left antennule, segment XXIII with 1s and separated from segment XXIV (Fig. 2C–D), segments XXIV–XXVIII with 12s + 2ae. In specimen 1, segments I–V fringed with long setules along posterior margin; in the other specimens setules absent.

Antenna (Fig. 2E–F), coxa without seta, basis with 1 seta, first endopod segment nearly as long as exopod, with 1 seta and without minute spinules distally, second with 3 + 5 setae and without spinules; exopod indistinctly 10-segmented, setal formula 0,0,0,1,1,1,1,1 0 and 2 setae.

Mandible (Fig. 3A–C), gnathobase strong, without setules; cutting edge with 3–4 acute teeth, dorsal most bifid at tip, possessing 4 small spines nearly at its basement; basis without setae and with 2 patches of minute spinules, exopod 5-segmented, with 1, 1, 1, 1, and 2 setae; endopod rudimentary 1-segmented with 2 setae of unequal length.

Maxillule (Fig. 3D), praecoxal arthrite without spinules, with 6 terminal spines, all lacking strong spinules; coxal endite with 1 seta, coxal epipodite with 3 setae and scar in one limb of holotype or 3 setae (holotype and paratype), basis without minute enditic seta and setules, endopod rudimentary, of one segment with 2 setae of unequal lengths, exopod with 3 setae.

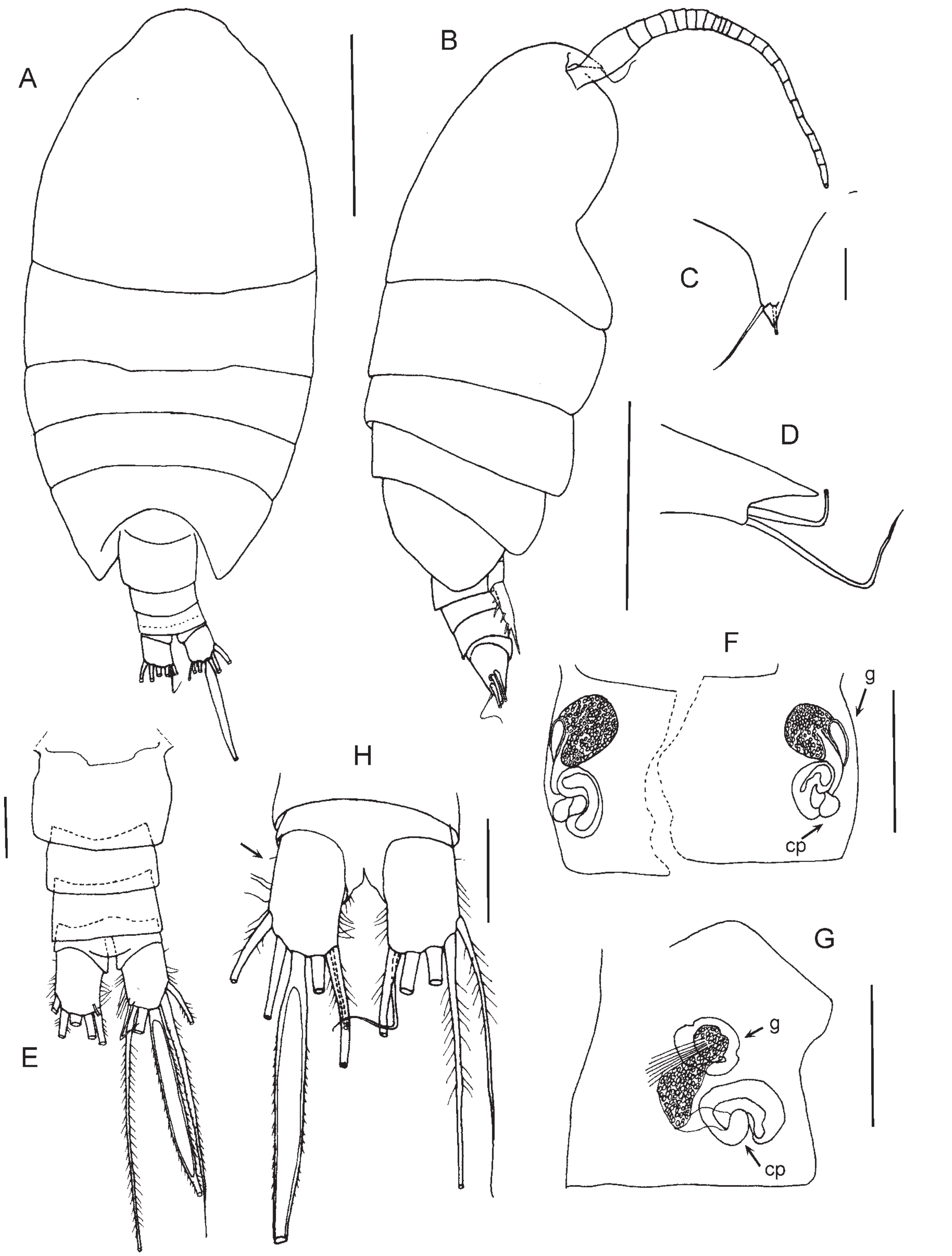


Fig. 1. *Crassarietellus septentrionalis* sp.n. Female, holotype: A — habitus, dorsal view; B — habitus, lateral view; C — rostrum, dorsal view; D — rostrum, lateral view; E — urosome, dorsal view; F — genital double somite, ventral view; «cp», copulatory pore, «g», gonopore; G — genital double somite, lateral view; «cp», copulatory pore, «g», gonopore; H — anal segment and caudal rami, ventral view. Scale bars: for A–B — 0.5 mm, remaining figures — 0.1 mm.

Рис. 1. *Crassarietellus septentrionalis* sp.n. Самка, голотип: A — общий вид дорсально; B — общий вид латерально; C — рострум, дорсально; D — рострум, латерально; E — уросома, дорсально; F — генитальный сомит, вентрально; «cp», копуляторная пора, «g», гонопор; G — генитальный сомит, латерально; «cp», копуляторная пора, «g», гонопор; H — анальный сегмент и каудальные ветви, вентрально. Масштаб: A–B — 0,5 мм, остальные рисунки — 0,1 мм.

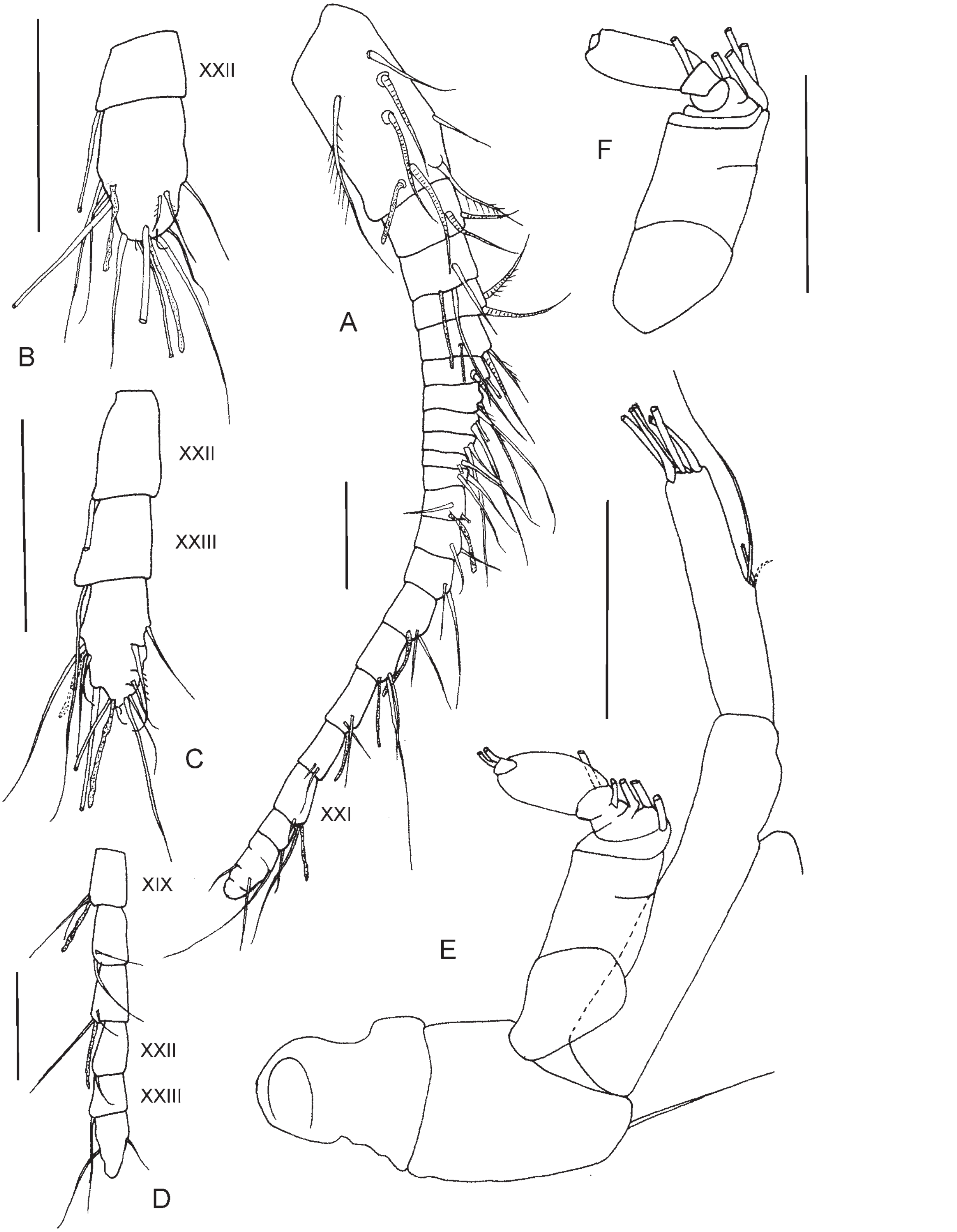


Fig. 2. *Crassarietellus septentrionalis* sp.n. Female, holotype: A — left antennule; B — left antennule, segments XXII–XXVIII; C — right antennule, segments XXII–XXVIII; D — right antennule, segments XIX–XXVIII; E — antenna; F — antenna, exopod. Scale bars 0.1 mm.

Рис . 2. *Crassarietellus septentrionalis* sp.n. Самка, голотип: A — левая антеннула; B — левая антеннула, сегменты XXII–XXVIII; C — правая антеннула, сегменты XXII–XXVIII; D — правая антеннула, сегменты XIX–XXVIII; E — антенна; F — антенна, экзоподит. Масштаб 0,1 мм.

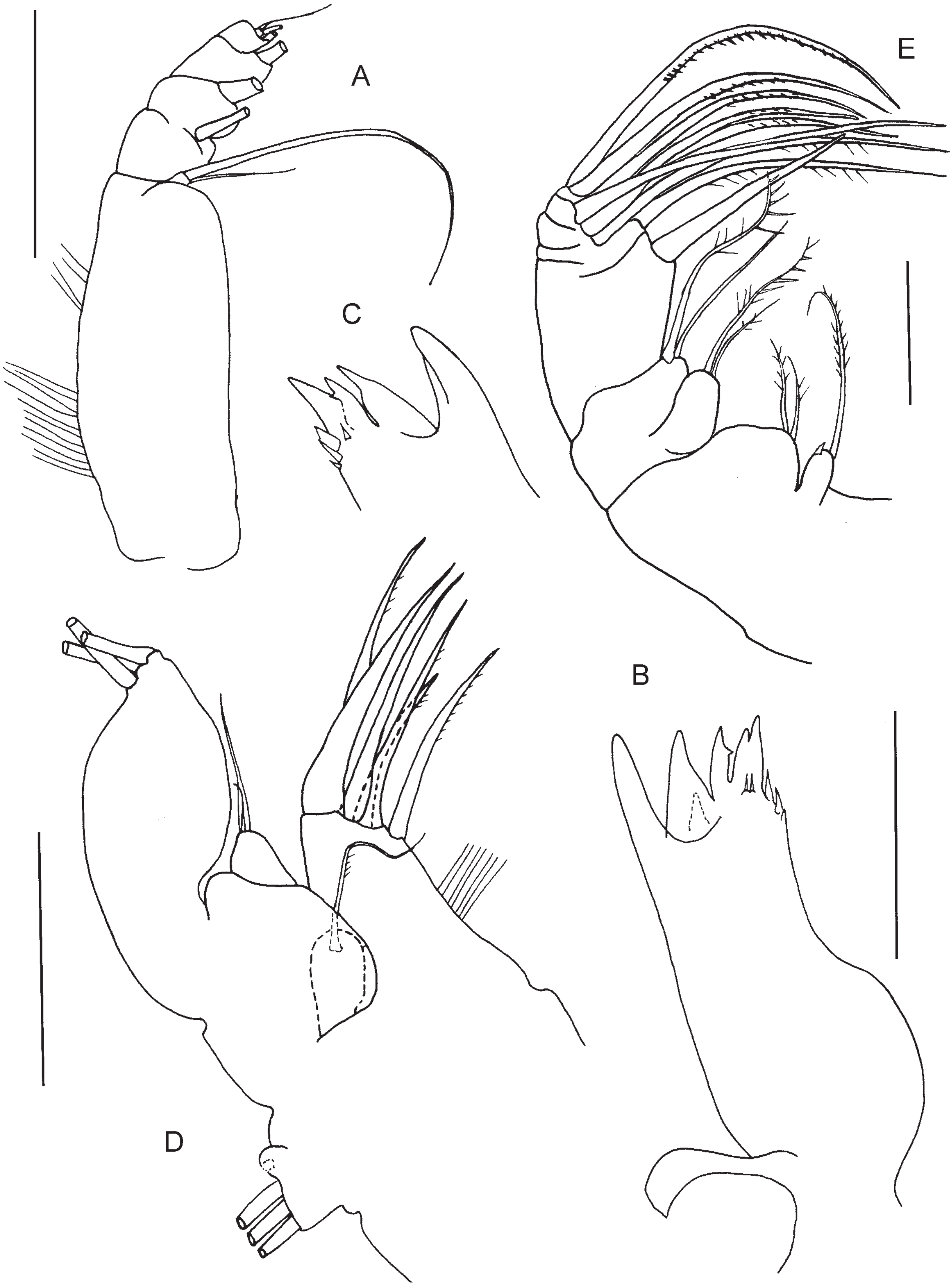


Fig. 3. *Crassarietellus septentrionalis* sp.n. Female, holotype: A — mandible, palp; B, C — mandible, gnathobase, different limbs; D — maxillule; E — maxilla. Scale bars 0.1 mm.

Рис. 3. *Crassarietellus septentrionalis* sp.n. Самка, голотип: A — щупик мандибулы; B, C — гнатобазы обеих мандибул; D — максиллула; E — максилла. Масштаб 0,1 мм.

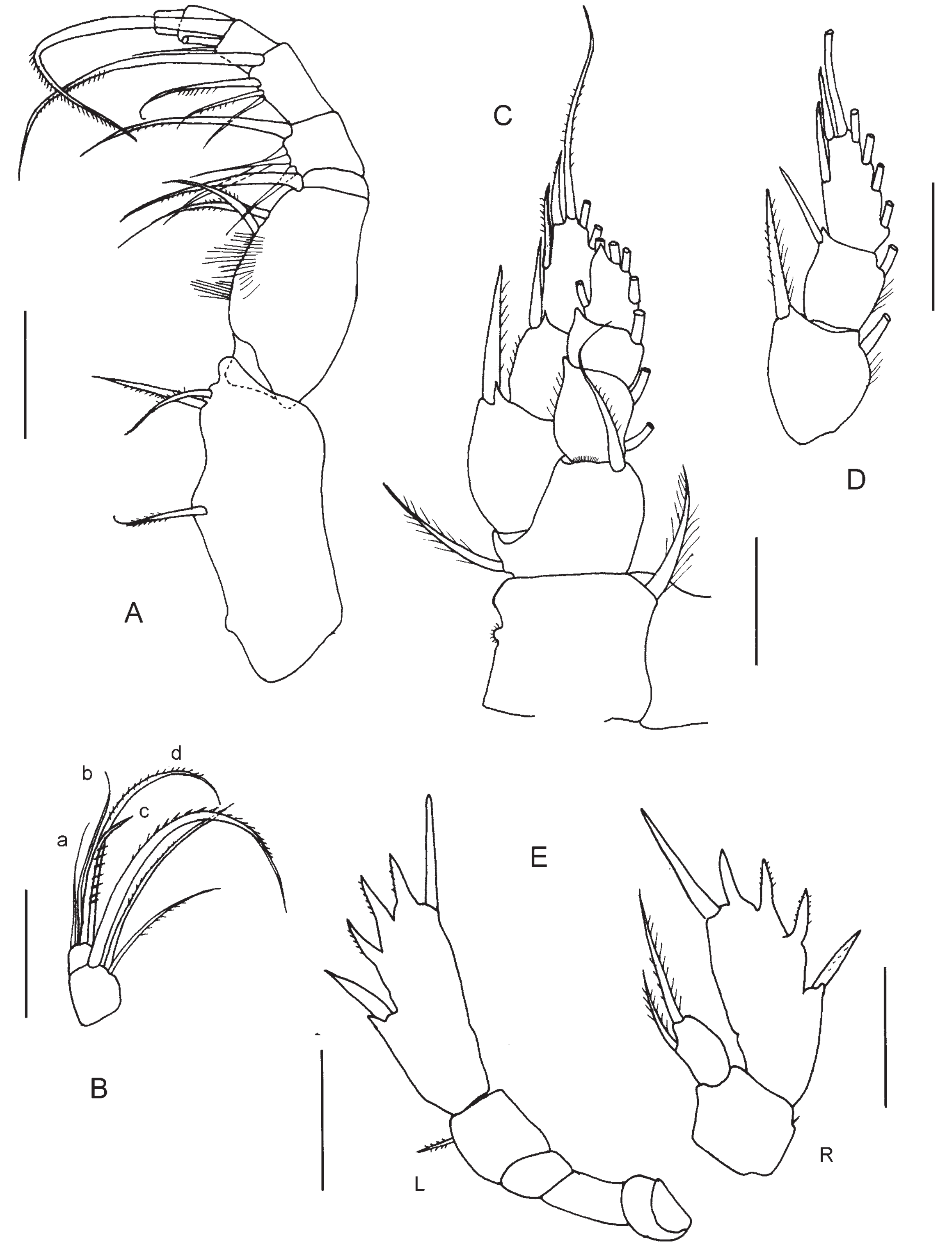


Fig. 4. *Crassarietellus septentrionalis* sp.n. Female, holotype: A — maxilliped; B — maxilliped, segments V–VI; «a», «b», outermost terminal setae, «c», «d», innermost terminal setae; C — P1; D — P1, exopod; E — P5 « L », left, «R», right. Scale bars 0.1 mm.

Рис. 4. *Crassarietellus septentrionalis* sp.n. Самка, голотип: A — максиллипеда; B — максиллипеда, сегменты V–VI; «a», «b», наружные терминальные щетинки, «c», «d», внутренние терминальные щетинки; C — P1; D — P1, экзоподит; E — P5 «L», левая, «R», правая. Масштаб: 0,1 мм.

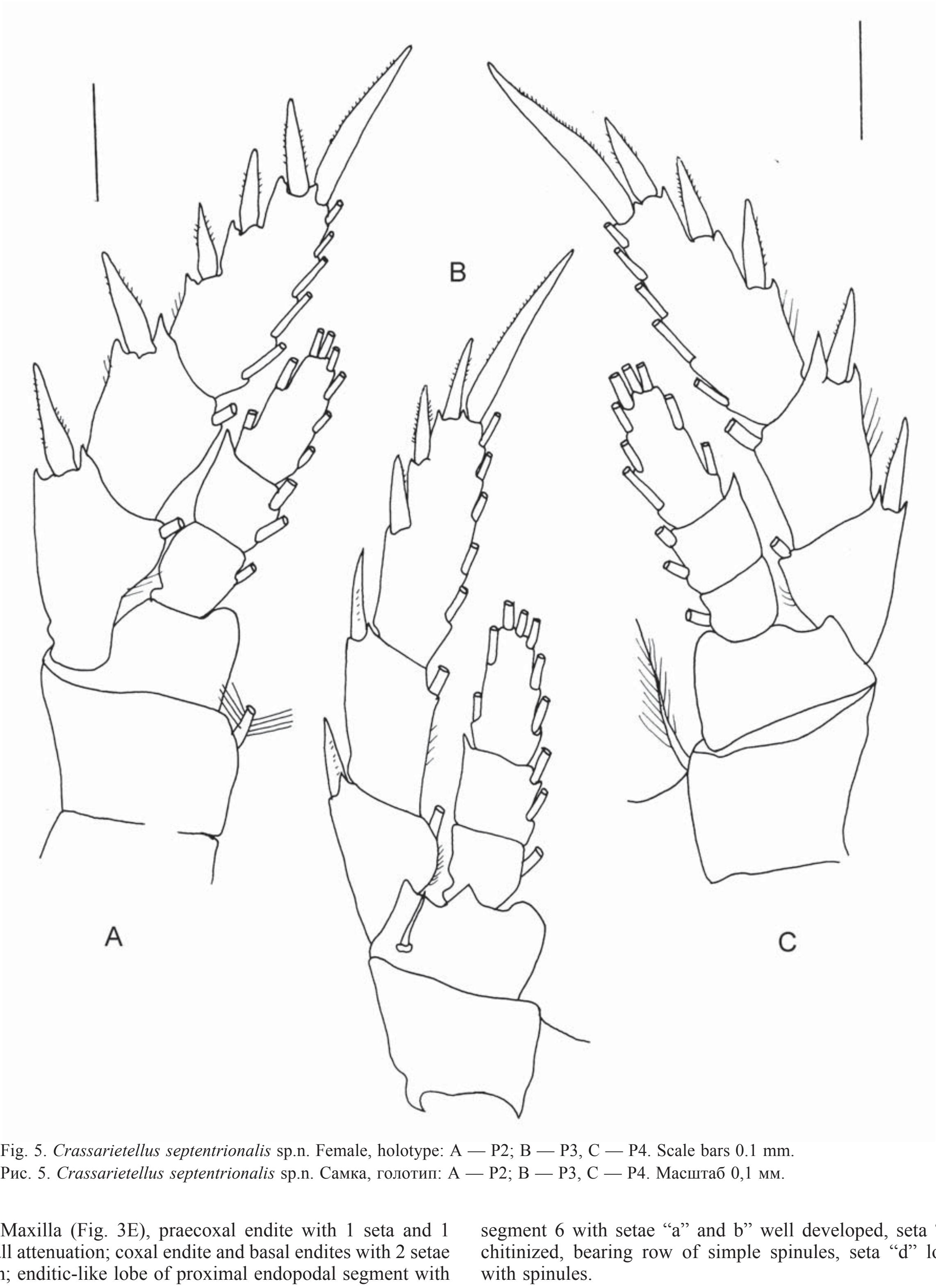


Fig. 5. *Crassarietellus septentrionalis* sp.n. Female, holotype: A — P2; B — P3, C — P4. Scale bars 0.1 mm.
Рис. 5. *Crassarietellus septentrionalis* sp.n. Самка, голотип: A — P2; B — P3, C — P4. Масштаб 0,1 мм.

Maxilla (Fig. 3E), praecoxal endite with 1 seta and 1 small attenuation; coxal endite and basal endites with 2 setae each; enditic-like lobe of proximal endopodal segment with strong spine, endopod of 4 segments with 8 strong setae.

Maxilliped (Fig. 4A–B), praecoxal endites of syncoxa with 0, 0 and 1 setae (from proximal to distal); coxal endite of syncoxa with 2 setae, basis with 2 medial setae and 2 patches of spinules proximally and in the middle of the segment; endopod with 1, 4, 4, 3, 3, and 4 setae; innermost seta on endopod segments 4 and 5 relatively long; endopod segment 6 with setae "a" and b" well developed, seta "c" chitinized, bearing row of simple spinules, seta "d" long with spinules.

P1 (Fig. 4C–D), coxa with medial seta and lateral knob at the middle length covered by short spinules; basis with lateral seta and medial seta distomedially slightly curved, anterior edge with tiny denticles along the base of endopod segment 1, details of Von Vaupel Klein's organ [Forshell, Ferrari, 2014] were not considered in this study; endopod 3-segmented; endopod segments 1 and 2 respectively with two

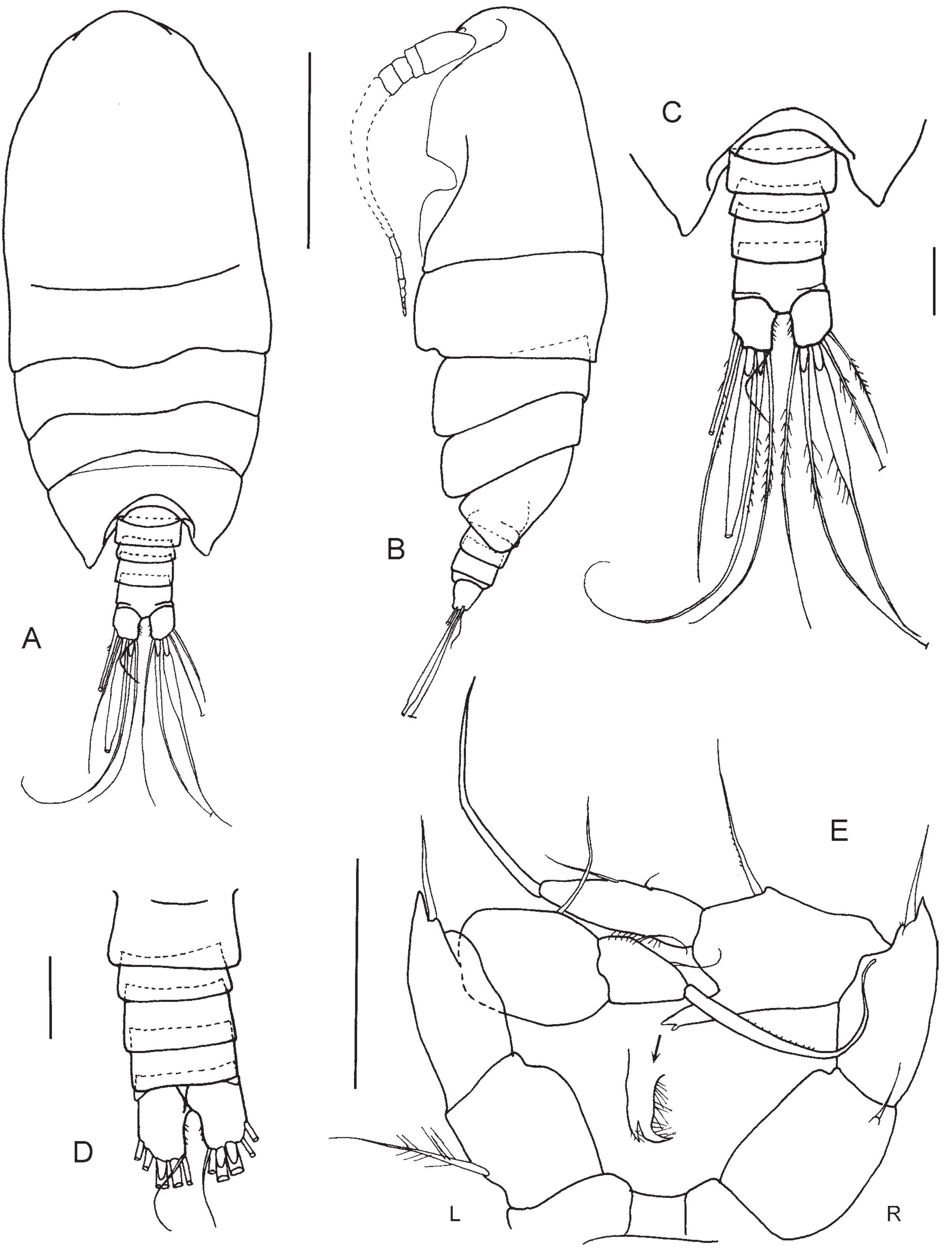


Fig. 6. *Crassarietellus septentrionalis* sp.n. Male: A — habitus, dorsal view; B — habitus, lateral view; C — posterior prosome and urosome, dorsal view; D — urosome, dorsal view; E — P5, « L », left, «R», right. Scale bars for A–B — 0.5 mm, remaining figures — 0.1 mm.

Fig. 6. *Crassarietellus septentrionalis* sp.n. Самец: A — общий вид дорсально; B — общий вид латерально; C — задняя часть просомы и уросома, дорсально; D — уросома, дорсально; E — P5, «L», левая, «R», правая. Масштаб: A–B — 0,5 мм, остальные рисунки — 0,1 мм.

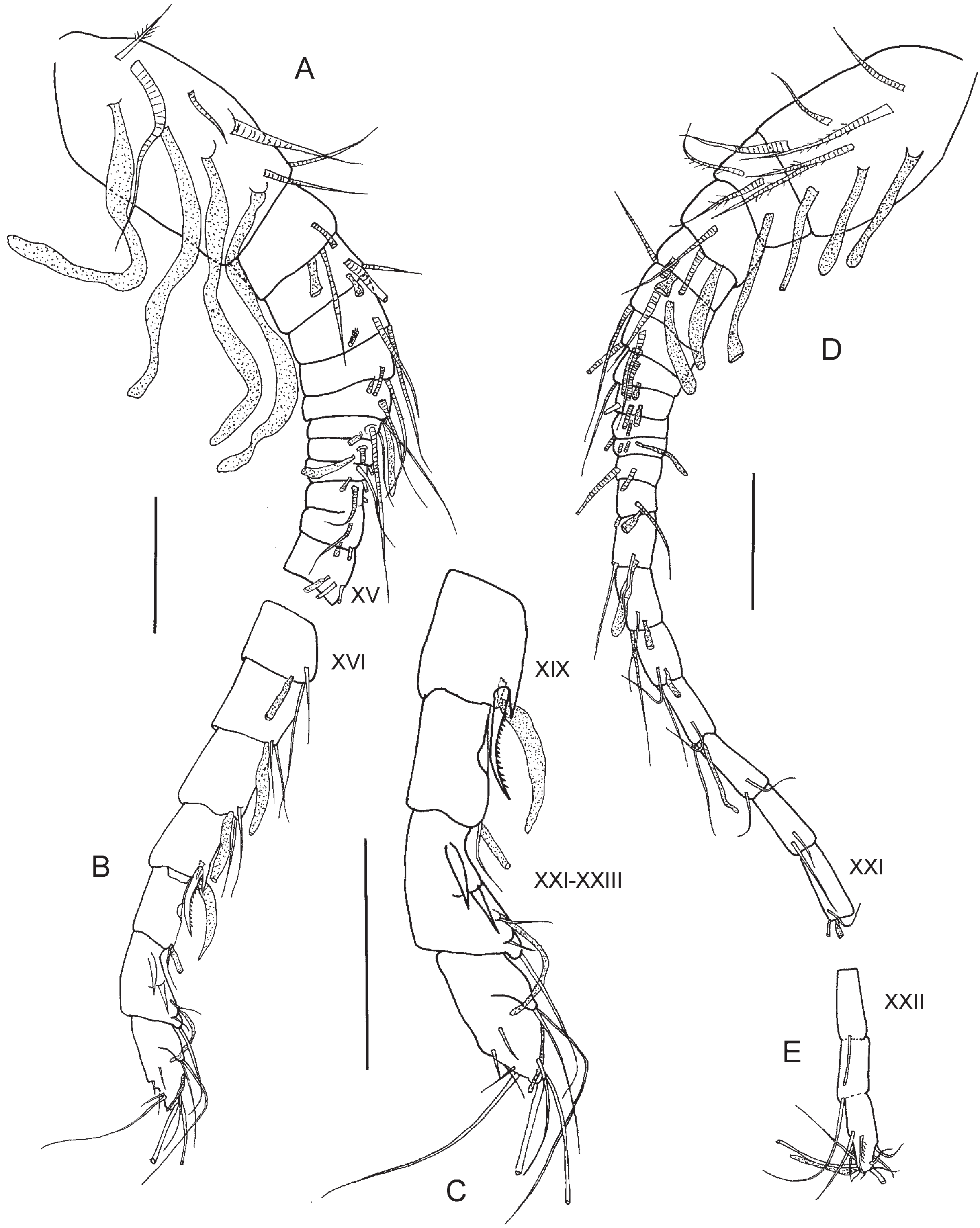


Fig. 7. *Crassarietellus septentrionalis* sp.n. Male: A — left antennule, segments I–XV; B — left antennule, segments XVI–XXVIII; C — left antennule, segments XIX–XXVIII; D — right antennule. Scale bars 0.1 mm.

Рис. 7. *Crassarietellus septentrionalis* sp.n. Самец: A — левая антеннула; сегменты I–XV; B — левая антеннула, сегменты XVI–XXVIII; C — левая антеннула, сегменты XIX–XXVIII; D — правая антеннула. Масштаб 0,1 мм.

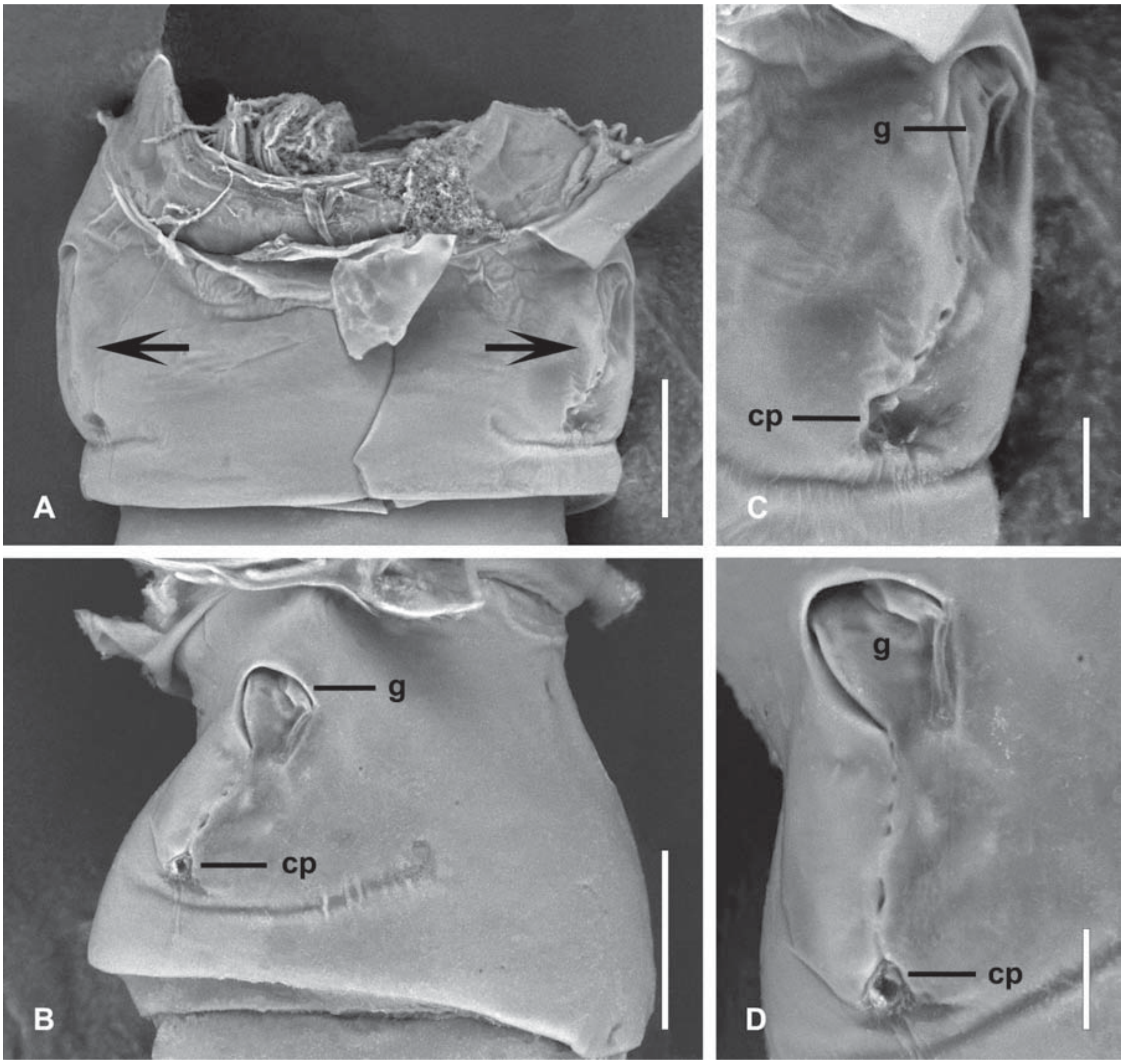


Fig. 8. *Crassarietellus septentrionalis* sp.n. Female: A, C — genital somite of additional specimen 1, ventral view; «cp», copulatory pore, «g», gonopore (arrowed); B, D — genital somite of additional specimen 2, lateral view; «cp», copulatory pore, «g», gonopore (arrowed). Scale bars: A, B — 50 µm, C, D — 15 µm.

Рис. 8. *Crassarietellus septentrionalis* sp.n. Самки: A, C — генитальный сомит первого экземпляра, вентрально; «cp», копуляторная пора, «g», гонопор (указаны стрелками); B, D — генитальный сомит второго экземпляра, латерально; «cp», копуляторная пора, «g», гонопор (указаны стрелками). Масштаб A, B — 50 мкм, C, D — 15 мкм.

and one medial setae, segment 3 with one lateral seta, two terminal setae and one medial seta; exopod segment 1 with lateral spine of exopod segment 1 extending to mid-length of the exopod segment 2 lateral spine and with medial seta; exopod segment 2 with lateral spine reaching nearly to first third-length of the exopod segment 3 lateral spine and with medial seta, and exopod segment 3 with two lateral spines, terminal spine and four medial setae.

P2–P3 (Fig. 5A–B), coxa with medial seta; basis without seta; endopods and exopods 3-segmented; endopod segment 1 with one lateral seta, endopod segment 2 with two lateral setae and endopod segment 3 with two lateral, two terminal and four medial setae; exopod segments 1 and 2 with one lateral and one medial seta, segment 3 with three lateral, one terminal spine and five medial setae.

P4 (Fig. 5C), coxa without medial seta; basis with seta in proximal part of the segment laterally; endopod segment 1 with one medial seta, segment 2 with two medial setae and segment 3 with two lateral, two terminal and three medial setae; exopod segments 1 and 2 with one lateral and one medial seta, segment 3 with three lateral spines, one terminal spine and five medial setae.

P5 (Fig. 4E), right and left coxae separate from intercoxal sclerite and basis; right basis with small lateral spine (holotype), or without spine (paratype, specimens 1 and 2), left basis with developed lateral seta (holotype, paratype and specimen 1), or without seta (specimen 2); endopod 1-segmented, present at the right leg with 1 seta (specimen 2), or two setae (holotype, paratype and specimen 1); exopod 1-segmented with one lateral spine, two lateral and one terminal spine-like attenuations and one inner spine.

Adult male, total length 1.50 mm, prosome 4.2 times as long as urosome. Cephalosome and pediger 1 separate, pedigers 4 and 5 fused; posterior corners of prosome produced

into rounded lobes, slightly asymmetrical, left reaching middle of urosome somite 3 (Fig. 6A–C). Urosome of five segments, integument not pitted (Fig. 6D). Rostrum as in female. Caudal rami symmetrical, longer than wide, without seta I, setae II–VI well developed, seta IV differs from setae II–III and V–VI in the peculiar swollen shape, seta VII originating dorso-medially near base of seta VI (Fig. 6A).

Antennules (Fig. 7A–E), right antennule non-geniculated, reaching to the anterior border of pedigerous somite 1, of 22 free segments (Fig. 7D–E); armature as follows: I–III–6s+3ae,

IV–X–2s+ae, XI–2s, XII–2s+ae, XIII–2s, XIV–XIX–2s+1ae, XX–2s, XXI–2+ae, XXII–XXIII–1s each, XXIV–XXVIII–11s+ae. Left antennule geniculated, reaching the middle length of pedigerous somite 1, of 19 free segments (Fig. 7A–C); armature as follows: I–IV–6s+4ae+2?, V– XII–2s+ae, XIII–2s, XIV–XVIII–2s+ae, XIX–1 spine with denticles+2 sharpen attenuations +1ae, XX–1s+1ae, XXI–XXIII fused, with 3s+2 processes+1ae, XXIV–XXVIII–10s+2ae.

Antenna, mandible, maxillule, maxilla, maxilliped (setae at segments 4 and 5 partly broken) and P1–P4 as in female, except for: mandible basis without setae and with two patches of minute spinules.

P5 (Fig. 6E), right and left coxae articulates with the intercoxal sclerite; basis articulates with the coxa, and has small setae at the right basis and well-developed plumose seta at the left basis; both legs lacking endopod; exopods 3-segmented, left and right exopod segments 1 with spine and pointed attenuation distally. Left leg exopod segment 2 oval, longer than wide and possesses lateral spine; segment 3 smaller then segment 2, tapering distally, with two short lateral setae and terminal spine. Right leg exopod segment 2 with lateral spine and medial bifid attenuation (arrowed on Fig. 6E); exopod segment 3 nearly as long as segment 2, possess two spine-like small lateral spines and terminal spine.

ETYMOLOGY. The species name "*septentrionalis*" means "northerly" and refers to the finding of the species in the high Arctic.

REMARKS. The new species shares with the arietellid genera *Crassarietellus* and *Campaneria* Ohtsuka, Boxshall et Roe, 1994 the possession of two lateral spines on exopod segment 3 of P1 and the possession of fewer than 8–9 setae on the maxillule epipodite [Komeda *et al*., 2021].

The male of the new species differs from the monotypic genus *Campaneria*, described from one male specimen, in the following characters: 1) the antenna exopod is indistinctly 10-segmented (vs indistinctly 8-segmented in *Campaneria*); 2) the innermost seta of the maxilliped endopod segment 5 is well developed (vs short in *Campaneria*), and 3) the outermost seta of the maxilliped endopod segment 6 is not rudimentary (vs rudimentary in *Campaneria*).

The species *Crassarietellus septentrionalis* sp.n. shares with the genus *Crassarietellus* the main characters of the body structure and the morphology of oral parts and swimming legs [Ohtsuka *et al*., 1994]. The new species, however, does not completely fit to the generic key characters of *Crassarietellus* [Ohtsuka *et al*., 1994; Komeda *et al*., 2021] and differs in lacking a ventral flap on the genital double-somite (vs present in female of *Crassarietellus*), absence of serrations on the spines of the maxillule praecoxal arthrite (vs serrated in *Crassarietellus*) and having the maxillule epipodite with 3–4 setae (vs 6 setae in *Crassarietellus*).

Considering these differences, *Crassarietellus septentrionalis* sp.n. is only tentatively placed in the genus *Crassarietellus*, until new material will be obtained and will permit clarification of its taxonomic status.

The females and male of *Crassarietellus septentrionalis* sp.n. investigated here differ from other members of *Crassarietellus* in the peculiar swollen shape of the IV caudal rami seta (Figs 1H, 6A), the unpitted integument and the smaller size (1.50–1.85 mm vs 2.80–3.85 mm).

Female specimens of *Crassarietellus septentrionalis* sp.n. differ from *Crassarietellus huysi* (described from females) in the following characters: 1) the left antennule has 21 distinctly free segments, segment XXIII is fused to segment XXIV (vs both antennule are 22-segmented in *C. hyusi*), the armature of segments IV, VI, VIII to XIII and XV to XVI is with 2s each, (vs 2s+1ae at each of these segments in *C. hyusi*); the right antennule has 22 distinctly free segments, with segments XXIII and XXIV separate; 2) the antenna endopod segment 1 does not have minute spinules distally and the exopod has 2 terminal setae (vs endopod has spinules and exopod segment has 3 terminal setae in *C. hyusi*); 3) the mandible gnathobase is strong, has no setules (vs with setules in *C. hyusi*); 4) the maxillule praecoxal arthrite has no spinules and terminal spines are not serrated (vs spinules present and terminal spines are serrated in *C. hyusi*), the coxal epipodite has 3–4 setae (vs 6 setae in *C. hyusi*), and the basis has no setules and minute enditic seta (vs with setules and enditic seta in *C. hyusi*); 5) the maxilla praecoxal endite has 1 seta (vs 2 setae in *C. hyusi*).

The male specimen of *Crassarietellus septentrionalis* sp.n. differs from *Crassarietellus* sp. (known after a male) in the following details of the armament of the left, geniculate antennule: segments I–IV–6s+4ae+2? (vs 9s+4ae in *Crassarietellus* sp.), segment XIII–2s (vs 2s+1ae in *Crassarietellus* sp.), segment XX–1s+1ae (vs 2s+process in *Crassarietellus* sp.), segments XXI–XXIII–3s+2 processes+1ae (vs 1s+2 processes+1ae in *Crassarietellus* sp.), segments XXIV–XXVIII–10s+2ae (vs 12s+2ae in *Crassarietellus* sp.).

The fewer number of setae on segments XXIV–XXVIII compared to *Crassarietellus* sp. may be due to their breakage in the studied specimen.

The P5 of *Crassarietellus septentrionalis* sp.n. differs from P5 of *Crassarietellus* sp. in the fact that both legs are lacking endopods (vs left leg possess endopod in *Crassarietellus* sp.), and the terminal spine of the left P5 exopod segment 3 is much longer than exopod segment 2 (vs terminal spine as long as exopod segment 2 in *Crassarietellus* sp.). *Crassarietellus* sp. is missing the description of the right P5 exopod segments 2 and 3, thus, their comparison with a new species is impossible.

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Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical approval: No ethical issues were raised during our research.

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